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# The Impact of School Lunch Length on Children's Health

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**Abstract**

The large number of overweight children in the U.S. has led school administrators and researchers to examine how aspects of the school environment affect children's dietary behavior and health. In addition to consuming nutrient rich food and exercising regularly, nutritionists have suggested that it is important for children to have an adequate amount of time to eat meals. This is because individuals only begin to feel full twenty minutes after they start eating, and as a result, those with a short meal period are more likely to overeat because they do not recognize that they are full within the meal period. This paper examines whether the length of time children are assigned to eat lunch in school has an impact on their nutritional health (as measured by BMI) using data from the School Nutrition Dietary Assessment-III. A parsimonious OLS specification suggests that a ten minute increase in a child's assigned lunch length significantly decreases the probability of being overweight by 1.83 percentage points and reduces BMI by 0.187 points. These results may be biased if there are unobserved characteristics of children and/or schools which are correlated with lunch length and are predictors of BMI. I address this endogeneity in two ways: First, I include an exhaustive set of controls for schools' nutrition policies and children's diet and exercise behavior that are intended to proxy for these unobserved characteristics. The results indicate a similar impact of lunch length: A 1.86 percentage point decrease in the probability of being overweight and a 0.194 reduction in BMI. Second, I include school fixed effects which control for factors that are common to children attending the same school, and find a 10 minute increase in lunch length predicts a 0.227 point decrease in BMI. Although the identification strategy cannot control for the non-random selection of children into schools, the proximity of these estimates to the initial results suggests that there is indeed a negative impact of short lunch length on health. Moreover, this observed relationship does not seem to be explained by unobserved differences among children and schools with different lunch lengths.

JEL Classification: *I10, I20*

Keywords: *childhood nutrition, school lunches*

## 1 Introduction

The large number of overweight school children in the U.S. has been a major source of concern for health professionals and educators. For the years 2003 to 2006, 12.8% of all 2 to 5 year olds were considered overweight, and the percentages were even higher for older children: 17.0% of 6 to 11 year olds, and 17.6% of 12 to 19 year olds [17]. These figures are based on the Center for Disease Control's

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classification system, which defines an overweight child as having a Body Mass Index (BMI) at or above the $95^{th}$ percentile of a historic baseline for age and gender specific BMI.[1] It is well-documented that overweight children are at risk for high blood pressure, high cholesterol, are more likely to be diagnosed with Type 2 diabetes, and continue to be overweight or obese as adults [11, 23, 26]. The economic costs of being overweight are non-trivial; Wang et al. (2002) calculate that 1.7% of total hospital costs from 1997-1999 were due to weight related medical care for 6 to 17 year old children. In an effort to explain the high rate of overweight children, researchers have examined how various features of the school environment affect children's nutrition and dietary habits. Children spend over 900 hours in school each year, and a healthy school environment which emphasizes nutrition education, physical activity, proper eating habits, and serves nutrient-rich food is considered essential in order for children to maintain a healthy weight (SNA, 2005). Thus far, researchers have found that physical education requirements, access to vending machines, and the nutrition content of school lunches do have a perceptible impact on children's weight [2, 1, 21].

One aspect of the school environment that has received considerable attention in the media and politics, but less in research, is the length of time children are given to eat lunch in school.[2] Specifically, many nutritionists and health educators argue that children need an "adequate" amount of time to eat their lunch in order for them to consume a healthy amount of food. The National Association of State Boards of Education, and the School Nutrition Organization have all formally recommended that schools provide students with at least 20 minutes to eat lunch-once they are seated-and 10 minutes for breakfast if offered [22, 15].[3] In addition, representatives from Massachusetts even proposed a bill in 2005 requiring every school district in the state to provide a mandatory 30 minutes for lunch.[4] The only source (to my knowledge) of nationally representative data on school lunch lengths, the School

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[1]Body Mass Index is calculated as: $\frac{weight(kg)}{height^2(m^2)}$ and acts as a measure of an individual's body fat. The CDC applies the term overweight (obese) to children (adults) with a BMI at or above the $95^{th}$ percentile, and the term at risk for overweight (overweight) for children (adults) with a BMI between the $85^{th}$ and $95^{th}$ percentile. The term obese is not applied to children to avoid possible stigmatization. For more information see: http://www.cdc.gov/nccdphp/dnpa/obesity/childhood/index.htm.

[2]This paper focuses on school lunch length and not breakfast length simply because not all children eat breakfast at school. In 2006, close to 83% of schools that offered a lunch period also served breakfast and provided space for children to eat. However, the numbers of kids actually eating breakfast at school seems to be small: For every 100 students who eat and receive a free/reduced price lunch, 44 students eat and receive a free/reduced priced breakfast [10].

[3]Another organization, the Partnership to Promote Healthy Eating in Schools-a joint effort between the U.S. Department of Agriculture and medical and health groups-does not recommend a specific length, but only that children are given "sufficient" lengths of time to eat. The SNA, NASBE, and PPHES also recommend that children eat as close to the middle of the school day as possible.

[4]This bill was proposed by Representative Joyce Spiliotis-Peabody, Massachusetts. See http://www.mass.gov/legis/member/jas1.htm for more information.

Nutrition Dietary Assessment-III (*hereafter, SNDA-III*) indicates that lunch periods for elementary, middle, and high schools vary anywhere from 10 to 120 minutes, with the majority of schools allocating between 15 and 60 minutes.[5] These lunch lengths include the travel time to and from the cafeteria, time spent in service (purchasing the meal or à la carte items), organizing and cleaning up, and time spent socializing, hence the actual time left for eating can be substantially less. According to observational studies conducted by the National Food Service Management Institute, in order for children to have 20 minutes of eating and socializing time at a lunch table, they need 26 minutes in the cafeteria (an average of 3 to 8 minutes is spent in service, and 1 minute spent cleaning), and 4 minutes to travel to and from the cafeteria [5].

How can the length of lunch periods (or any meal) affect children's weight and health? Medical research indicates that it takes approximately 20 minutes for the brain to realize that an individual is getting full once he/she starts eating. Experiments show that when people are given a short length of time to eat, they tend to overeat, because they do not feel full within the meal period. In contrast, when people are given more time to eat, they realize that they are getting full and will taper their consumption [20, 28]. This implies that, ceteris paribus, a student who has more time to eat lunch is less likely to overeat than a child with a shorter meal period. If both students have the same food options, but different meal lengths, presumably some food is just not consumed, or extra food is not purchased. In addition, short meal periods may encourage individuals to skip meals, causing students to overeat during other times, or choose faster and less nutritious options such as vending machine food [6].

This paper examines whether short lunch lengths adversely impact the dietary and nutritional health of children. Ideally, this could be done over the short and long run: Measure the impact of lunch length on the number of calories, or fat/sugar intake during a single meal (short run), and then examine how this every day behavior translates in the long run onto a more cumulative indicator of weight and health like BMI. Unfortunately, data limitations restrict this study to the latter, and hence I can only estimate the impact that lunch length has on BMI and the probability of being overweight.[6]

The results from a simple OLS regression of these health outcomes on lunch length and a few basic school and child controls, suggests that there is a negative and statistically significant effect: A 10 minute

[5] 1% of the SNDA-III sample lies below 15 minutes, and 1.5% lies above 60 minutes. The SNDA-III sample size is 1,408 children, from 199 schools.

[6] The SNDA-III does contain a 24 hour dietary diary for each child which contains information regarding all the food a child ate over a random school day, however, at the time of this research, this information is not a part of the public-use file. No part of the SNDA-III includes information on academic or behavior outcomes of children. The impact of lunch length on these outcomes would be interesting to study, as previous research suggests there is a relationship between food consumption, academic progress, and behavior [7, 8, 24].

increase in a child's assigned lunch period is predicted to decrease BMI by 0.187 points, and this reduces the probability of being overweight by 1.83 percentage points. These OLS estimates may not represent the causal effect of lunch length if there are some unobserved characteristics of schools and/or children which are related to the length of lunch and are predictors of BMI. For instance, schools that promote good nutrition and physical education practices may assign lengthy lunch periods, and it may be this focus on good nutrition that results in fewer overweight students rather than the longer lunch. Moreover, children that have healthy eating and exercise habits may select into schools with lengthy lunch periods, and this may result in fewer overweight children at schools with generous lunch periods.

I address the endogeneity of lunch length in two ways: First I add a series of covariates regarding each school's dining and nutrition education environment, and controls for each child's eating and exercise habits at home and at school. These covariates are intended to proxy for any unobserved characteristics that may be correlated with lunch length. Despite being strong predictors of BMI, their inclusion only slightly alters the magnitude of the estimates: A 10 minute increase in lunch length reduces the probability of being overweight by 1.86 percentage points, and BMI by 0.194 points. Second, I include school fixed effects. This specification allows me to eliminate any constant unobserved characteristics of schools, and relies on variation in lunch lengths across children within a school for identification. There are only a handful of schools in the data where this occurs, and so the resulting estimates are measured imprecisely. However, the magnitude and sign are similar: An extra 10 minutes decreases BMI by 0.227 points. These results suggest that differences among children and schools in unobserved characteristics do not explain the observed relationship between lunch length and BMI. In addition, I examine whether the lunch length finding is confounded by the effect of when children eat, and what role measurement error may play for the results. The estimates are robust to these factors.

The remainder of this paper is organized as follows: In Section 2 I discuss evidence from the medical literature regarding meal lengths and consumption, and describe the current economics literature on schools and children's nutrition. Sections 3 and 4 discuss the data and the empirical strategy. In Section 5 I discuss the results from the OLS estimation, the robustness checks, and the school fixed-effects estimation. Section 6 concludes.

# 2 Background & Related Literature

## 2.1 Appetite & Satiety

To understand why short lunch lengths may lead to overconsumption, it is important to consider the physiological mechanisms behind appetite and eating. When an individual eats, nerves in the stomach send signals to the portion of the brain that controls appetite, the hypothalamus. These stomach signals tell the hypothalamus that the individual is getting full, and consequently, the hypothalamus relays a message to the rest of the brain to stop eating. It takes close to twenty minutes for these satiety signals to reach the brain, and only then will a person begin to actually feel full and stop eating. At an extreme then, individuals could eat close to twenty minutes more worth of food than the body actually desires. When an individual has a short time to eat, he/she adopts a quick pace of eating, relative to when there is a longer time frame, where intake can be spread out [20, 28]. As a consequence, when meal lengths are short, people eat rapidly, and because it's unlikely that they feel full during the meal period, they eat throughout it. In contrast, during long meal periods, intake is spread out, and it's likely that people begin to feel full and hence taper their consumption. This implies that two individuals with the same meal options but different lengths of time to eat can end up with vastly different intake: By the time they both begin to feel full, the one with the shorter meal length has eaten more than the one with the longer length.

A number of studies in the medical literature provide evidence of this phenomena. Melanson et al. (2006) conducted a controlled experiment where college-aged, normal-weight women, ate a provided lunch on two separate occasions. On one occasion the women were asked to eat quickly and on the other occasion were asked to place their utensil down on the table between bites, thus slowing down eating. During the rapid eating meal, participants consumed an average of 646 calories per person in nine minutes, while during the other meal, the average consumption over 29 minutes was only 579 calories per person. Moreover, an hour after each group ate, those that ate quickly reported being less satisfied with their meal [13]. Similar results were found for overweight men in another controlled experiment where researchers varied the timing of when indivdiuals were allowed to take a bite of foot. All individuals were given an unlimited amount of time to eat and told to eat until they felt full. The experimental group could only take a bite of food about half as often as the control group, and researchers found those who were forced to slow down ate substantially less than those that were not constrained [14]. Although none of these studies directly involve children, there is no indication that they would behave differently.

### 2.2 School Environment & Children's Nutrition

This paper contributes to the growing literature which analyzes the impact of school characteristics on the nutritional behavior of children. Cawley et al. (2007) examine how physical education classes affect the amount of physical activity children perform, and the subsequent impact on being overweight. Using variation across states and time in physical education requirements, they find that physical education classes increase the number of minutes a child is physically active by 31 minutes, but has no discernable impact on BMI or being overweight. Schanzenbach (2009) examines the quality of food served in the National School Lunch Program, a program which serves over 25 million children each school day. She finds that those students who eat a school lunch consume 40 to 120 more calories per lunch than those that pack, and this increases the probability of being overweight by two to four percentile points. Anderson et al. (2004) examine the controversial placement of vending machines in schools (often used to generate additional school funds) on the BMI levels of children. The authors find that a 10 percentage point increase in the probability of having access to vending machine food leads to a one percentage point increase in BMI.

Additionally, researchers have found that for schools that give recess (generally, elementary and middle schools), there is less food wasted when children have recess before lunch instead of after. The intuition is that if recess is placed after lunch, children do not concentrate on eating and hurry to attend recess [16, 12]. Finally, a 2004 observational study by the National Food Service Management Institute on plate waste directly compares the intake of children with a 20 minute lunch versus those with 30 minutes. For the children that received 20 minutes, there was a food waste rate of 43.5%, while it was only 27.2% at the school with 30 minutes. Although this suggests that longer lunches are associated with eating more, the type of food consumed by students at the school with the longer lunch was more nutritious: 16% more vitamin A, 46% more calcium, and more macronutrients were consumed by the children with the longer lunch [16]. These results suggest that short lunch lengths may influence children to substitute towards less nutrient rich food, but unfortunately this channel can not be examined with the current data. It is important to note that this study was done using only two schools, hence the results should be interpreted with caution.

## 3 Data & Descriptive Statistics

The School Nutrition Dietary Assessment-III was sponsored by the U.S. Department of Agriculture in 2005 in order to collect information regarding school meal policies and food programs, the content and quality of food offered at schools, and children's dietary habits. The survey encompasses five groups: Children age 5 to 19 in grades 1 to 12, their parents, the principals of their schools, the food service managers at school, and the school food authority that governs their school. School food authorities (SFA) are the organizations responsible for overseeing all food related aspects-service, budget, management-of schools in a school district or county, and there are 130 SFA's in the SNDA-III. Approximately three schools (elementary, middle, high) in each SFA's jurisdiction were selected to answer the principal and food service manager survey for a total of 398 schools.[7] The principals of each school provided information about meal time policies (i.e. where children eat their meals, length of lunch period and which grades eat during each period) as well as information on the presence of vending machines, snack bars, and nutrition education. The food service managers are in charge of day-to-day food operations, and they provided information regarding kitchen characteristics and staff, meal prices, participation in subsidized meal programs, and the type and quantity of a la carte items available during meals. From the 130 SFA's and 398 schools, 94 SFA's and 288 schools were selected to have their students receive the child and parent survey. An average of 8 students from each school were selected to participate in the survey, and these children and their parents provided information on the child's eating and exercise habits at home and school (i.e. regularly eat breakfast, times per week they buy their lunch or snacks at school, what types of food they eat at home, how often they exercise/play), and standard demographic and geographic characteristics of the child and parents. The final component of the child's survey included a 24 hour dietary diary where consumption over a random school day was recorded, but at the time of this research, this was not available in the public use data. In addition to these survey components, each child's height and weight were measured by survey administrators and translated into a Body Mass Index. The total number of individual student is 2,314.

Children are not asked how long their lunch periods are, so to obtain a measure of each child's lunch period, I combine information from the principal and child survey. Principals were asked to report what time each lunch period begins and ends (most schools have multiple lunch periods) and which grades eat in each lunch period. The difference between the ending time and the starting time is the length of the lunch period. I match each child's self-reported grade with the lunch period in which principals reported that grade eats. One hundred and sixty six of these students attend schools where the same grade can eat in multiple lunch periods (i.e. some $6^{th}$ graders are assigned to eat in the first lunch period and others in the second period). The lengths of these potential lunch periods varies, so I assign

[7]All the schools selected for the survey were participants of the National School Lunch Program.

the average of these lengths to the child. There is an admittedly high non-response rate of principals to the lunch length question; only 199 schools provided information about the length of lunch despite the fact that all the schools in the sample serve lunch. In conversations between the author and survey administrators, it was determined that the questions about lunch length were only asked during an initial contact survey with principals (whereas most other information was asked during a later and more lengthy questionnaire), and no effort was-or is-being planned to follow-up on missing information.[8] Consequently, the final sample size of child observations used in the analysis is 1,408 students from 199 schools and 78 SFA's.[9]

Figure 1 displays histograms of lunch length (in minutes) separately by grade, for the 1,408 children. The minimum lunch length is 10 minutes, maximum is 120 minutes, and the average ranges from 31 to 37 minutes. The average for the entire sample is 34.10 minutes [s.d.=12.42] and the median is 30. Less than 1% of the sample has a lunch length less than 15 minutes, and less than 1.5% has a lunch length greater than 60 minutes. The histograms suggest that children in all grades face a similar range of lengths for lunch, and there's no indication that some grades receive systematically shorter/lengthier lunches than others. This is actually a little surprising, since generally children in younger grades receive a recess. However, it could be that recess time is not included in the lunch period length reported by principals, or that children that receive recess have the same amount of time for eating and recess as other children do just for eating. The average reported lunch length for children at schools that offer recess (N=557) is 34.24 [14.15], while it is 34.01 [11.14] for those that don't (N=851).

The highest number of lunch periods reported by schools in the SNDA-III is eight, the minimum is one, and the average is 3.3 lunch periods. Table 1 describes lunch period characteristics for schools with a given number of lunch periods.[10] The average lunch length, size of school, number of children eating during the lunch period, average time spent in service (i.e. time spent in line), and the earliest and latest starting times of lunch periods are reported. Schools that have a larger number of lunch periods tend to have shorter lunch periods; the average lunch length for schools with one lunch period is close to 50 minutes whereas the average length (across all periods) for schools with five lunch periods is close

[8]To assess whether this non-response is random, I compared the average characteristics of schools (size, grades served, nutrition and education policies, etc...) that reported lunch lengths with those that didn't. There do not seem to be any significant observed differences in these groups, so for the remainder of the analysis I assume non-response is random.

[9]In reality, the missing lunch information lowers the sample size to 1,652 children, but then missing information on key child/school/parent characteristics lowers the sample further to 1,408.

[10]Note: The averages were calculated at the individual level. However, since the same number of children were selected for participation from each school, we can interpret the averages at the school level without loss of generality.

to 30 minutes. Moreover, as the number of lunch periods increases, the length of time spent in service and the number of children eating within the period falls, indicating that lengthy lunch time may come at the expense of crowded cafeterias and long lines. Finally, the timing of lunch varies anywhere from 9:30 am to 2:00 pm. In Section 5, I examine what role eating early or late in the day may have for the lunch length results.

## 4 Empirical Specification

To estimate the effect of lunch length on children's health, I run the following OLS regression: $h_{is} = \beta_1 + \beta_2 L_{is} + \beta_3 X_{is} + \beta_4 S_s + \epsilon_{is}$. Here $h_{is}$ represents one of three health outcomes for child i at school s. The first is BMI (a continuous variable between 12 and 55), and the other two are standard percentile cutoffs for being overweight: Whether or not the child is strictly overweight (0,1 variable equal to 1 when BMI is at or above the historic $95^{th}$ percentile), and whether or not the child is overweight (0,1 variable equal to 1 when BMI is at or above the historic $85^{th}$ percentile). When the outcome is binary, I run a logit regression, and in the tables these estimates are converted to their marginal effects (evaluated at the mean) for ease of interpretation. $L_{is}$ is the length of a child's assigned lunch period in minutes. $X_{is}$ is a set of child and parent characteristics associated with each child, and $S_s$ are characteristics of the school which are the same for all children attending that school. For the fixed effects estimation, I include school fixed effects in the regression, which control for any unobserved characteristics of schools that affect children's health outcomes. Identification here relies on the schools where children within a school are assigned different lengths of time to eat. In the SNDA-III this only occurs across grades within a school (i.e. in the same school, $7^{th}$ graders receive 25 minutes while $11^{th}$ graders receive 30 minutes). Moreover, the sample of schools that assign different lengths to different grades is small: 44 schools with 305 children. The implications of this limited sample size will be discussed when the fixed effects are presented. I cluster standard errors at the school level in all regressions.

Table 2 describes the mean values of the covariates included in all regressions, separately for four groups of children in the first four columns, and then all together in the last column. These groups are divided by lunch length: 10 to 29 minutes, 30 minutes, 31 to 40 minutes, and 41 plus minutes. A cursory glance at the first few rows confirms the notion that children who attend schools with lengthier lunch periods have lower BMI values (at least starting from lunches greater than or equal to 30 minutes). Comparisons across groups suggests that schools are similar in many of the characteristics that can influence a child's weight: An equal proportion of schools allow children to eat in the cafeteria or on campus across lunch length groups, and the fraction serving breakfast is also similar. There are more marked differences in terms of whether or not children are allowed to leave campus for lunch, leave the eating area before the official lunch period ends, and their access to vending machines and school snack bars. It is surprising to see that schools with lengthier lunch periods are more likely to allow children to leave campus (and potentially purchase fast food meals), have vending machines, and are less likely to have nutrition programs. This runs contrary to what we expect to see if we associate lengthy lunches with schools that have other "good" nutrition practices.

Turning to the characteristics of children, we can see that children look similar in terms of sex and age, although there is variation in the fraction of minorities across these lunch length groupings. More importantly, there seems to be very little difference between groups with regards to their average eating habits: Similar fractions of students regularly eat breakfast (.73 to .75), eat school lunches 3 or more times per week (.74), take vitamins (0.55 to 0.58), and, according to parent responses, are healthy (0.78 to 0.82). Moreover, close to 60% of students in each group play sports, and 90% regularly exercise. This suggests that children who attend schools with long lunch lengths are no more healthy in their home eating and exercise habits than children who choose schools with short lunch periods. Finally, with the exception of the students with the shortest lunch lengths, the groups are similar in average income, suggesting that wealthier families may not necessarily send their children to schools with longer lunch periods. This is an important pattern to note, since, at least for white women (black men), there is a well-documented negative (positive) relationship between being overweight and income [4]. There are more pronounced differences in physical education participation, receipt of free/reduced priced lunches, and parents' education. Since the analysis in the following section will be unable to fully control for selection into schools, I take the similarity of children based on observable characteristics as a good indicator that they are also similar on unobservables.

# 5 Results

## 5.1 OLS Estimates

Table 3 displays the results from a set of OLS regressions. The first row displays the coefficient on lunch length when the dependent variable is BMI, second row when the dependent variable is being overweight and final row with dependent variable being strictly overweight. Column (1) reports the results from a regression where the only regressor is lunch length (and an intercept). Although the estimates are not statistically significant, their sign indicates a negative relationship between lunch length and BMI and being overweight.[11] Each consecutive column displays the coefficient estimates on lunch length from regressions where the following groups of controls are added: Geographic characteristics in column (2), school characteristics in (3), child characteristics in (4), parent characteristics in (5), both child and parent in (6), and all of these in (7). Each grouping is comprised of "standard" characteristics; for instance the child controls are age, sex, minority status, grade level, and whether the child receives a free/reduced price lunch. These standard controls are arguably very basic predictors of BMI in part because of their inclusion in other research on children's health, and because they are generally observed by the econometrician. The controls that are included in each group are listed in the footnote of Table 3, and hereafter are referred to as standard characteristics.

Consider the first row for illustration. Moving from left to right across the table, we can see the inclusion of geographic/interview characteristics changes the point estimates from -0.02036 to -0.02362, implying that differences in when children were interviewed and where they live (at a highly aggregated region level) explains only a small portion of the lunch length-health relationship. When school characteristics are included, the estimate changes by an even smaller amount, and now it is statistically significant. There is a substantial drop (in absolute value) when child characteristics are added, and an increase when parent/family information is controlled for. These diverging effects offset each other when both sets are included at the same time in Column (6). The final column depicts the "take-away" estimates from the table: When all standard covariates are included in the regression, a 10 minute increase in assigned lunch length is predicted to significantly decrease a child's BMI by 0.187 points. Moreover, turning to the second row, this 10 minute increase translates to a 1.83 percentage point decrease in the probability of being overweight, but no effect is found for the stricter definition of overweight.

As mentioned, the estimates in Table 3 may be biased by the presence of unobserved school and child characteristics that are correlated with lunch length and predict BMI. There can be a non-random adoption of lunch lengths by schools, and a non-random selection of children into schools with certain lunch lengths. For instance, many nutrition researchers have recommended that schools which are interested in cultivating healthy eating environments should offer lengthy lunches in addition to imposing strong physical education requirements and serving nutrient-rich food [22, 15, 18]. If these additional school factors are not adequately controlled for, the estimates of lunch length on BMI will be biased by the effect of these alternate factors on BMI. Moreover, it is widely acknowledged that parents often

[11] In addition, I include a control for whether or not the lunch length was averaged. As was discussed in Section 3, this was done for children who are in a grade that can eat in multiple lunch periods. This affects 166 students. This indicator is equal to 1 if the length was averaged, and is included in every regression. The estimate for lunch length is similar regardless of if the indicator is included or not.

make the decision of where to live based on the quality of schools that this allows them to send their children to. It could be that a family which practices healthy eating and exercise habits chooses to send their child to a school that offers lengthy lunches, and this selection will bias the OLS results.

In an attempt to eliminate the potentially confounding effect of these unobserved characteristics, I re-run the regressions from Table 3 but now include an exhaustive set of child, parent, and school characteristics as well. The additional school characteristics include indicators for where children eat (on campus, off, in a cafeteria), whether or not there are vending machines or snack bars on campus, the average time spent in line waiting for food, whether children are allowed to leave eating areas before the lunch period is over or must remain there, and whether or not the school participates in a certified nutrition program.[12] The additional child and parent characteristics include eating habits: does the child regularly eat breakfast, purchase school lunch 3 or more times per week, take vitamins, drink skim milk; exercise habits: does the child take a phys ed class, play on a sports team, play outside/exercise at home, time spent watching tv and on the computer; parental responses about health: does the child eat less or more than an average child, is the child healthy; and additional parent characteristics: highest education completed, marital status, number of household members, and spoken language.

These controls are added one set at a time, and the results are displayed in Table 4 in columns (2) through (5). Column (1) repeats the estimates from column (7) of Table 3. The inclusion of additional school characteristics reflecting the school nutrition environment lowers the estimates for BMI by less than 2%: Now a 10 minute increase in lunch length is predicted to decrease BMI by 0.184 points. However, a test of the joint significance for these additional controls reveals that they are not jointly significant, and do not add much new information to the regression. The results from Column (3) are more informative: When child characteristics are added, the estimates do not change substantially, even though these controls are strong predictors of BMI. The p-value on their joint significance ([0.000]) suggests that we can fail to accept the null hypothesis of joint insignificance, and the estimates indicate a 0.186 point decrease in BMI and a 1.7 percentage point reduction in the probability of being overweight. The results do not change substantially when parent characteristics are added either. Finally, when all regressors are included in column (6) the results indicate a 10 minute increase in assigned lunch length significantly reduces BMI by 0.194 points, and reduces the probability of being overweight by 1.86 percentage points. This is almost identical to the estimates when none of these additional controls are included: 0.187 reduction in BMI and 1.83 percentage point decrease in the probability of being

[12]Examples include 5-A-Day, USDA Team Nutrition.

overweight.

The results from Table 4 allow us to draw two conclusions: First, the results in column (6) provide a set of estimates which arguably control for many of the school food environment and child dietary and exercise behaviors that impact BMI. Second, comparing these results to the parsimonious OLS regression, we observe that there is not a substantial difference in the estimated impacts. This suggests that the role of unobservables may not be very important in explaining the relationship between lunch length and health. That is, since observed differences in children and schools with respect to nutrition and exercise practices explain little of the observed relationship between BMI and lunch length, it is unlikely that differences in unobserved characteristics do either. The inclusion of the additional covariates only serves to strengthen the negative relationship between lunch length and health outcomes (i.e. more precise estimates and slightly larger-in absolute value-point estimates). It is important to note though that if these additional regressors are not good proxies for unobserved characteristics, then the OLS estimates are still likely biased. This issue can be partly resolved by including school fixed effects, which is done in Section 5.3. This approach has some important limitations given the SNDA-III data, so before discarding the OLS estimates as biased, I analyze the robustness of these results.

## 5.2 Robustness of OLS Estimates

To assess the robustness of the OLS estimates from column (6) Table 4 (*hereafter, baseline estimates*), I first consider whether the averaging of lunch lengths affects the results. Recall, average lunch lengths were calculated for 166 observations because these children attend schools where the same grade can eat in multiple lunch periods. All previous regressions have included an indicator for whether or not the length was averaged, but in row (2) of Table 5, I omit those observations that were averaged entirely. Doing so reduces the sample size to 1,242 and only slightly increases the point estimates in absolute value (the first row repeats the baseline estimates). These new estimates are consistent with the predictions of measurement error theory: The averaging introduces noise into the true lunch length, which attenuates the estimates toward zero. Once the observations with measurement error are removed, the estimate is larger (in absolute value).

As another check of the estimates, I include information regarding the the number of children eating lunch during a child's lunch period into the regression. This was not included in prior regressions because a number of principals did not report this information. This variable is informative about the "traffic" a child faces while he/she eats: Competition for a seat in the lunchroom, congestion in the halls as he/she travels to and from lunch or uses the bathroom, etc... The inclusion drives the estimates on lunch length closer to zero, and it becomes insignificant. This is likely an artifact of the reduced sample size and not because number of kids eating explains the lunch time-BMI relationship, since the coefficient on the variable itself is is virtually zero.

In the fourth row, I include indicators related to how hungry a child is when he/she eats lunch. These include length of the school day in minutes, minutes from the start of the day until lunch, and an indicator equal to one for whether or not the child eats within 30 minutes of the midpoint of the day. Again, these variables were not included in prior regressions because a number of principals did not report them. Length of the day and time between the start of the day and lunch reflect how long a child is in school without eating, and this can ultimately impact their hunger levels, snacking and lunchtime food consumption. In addition, organizations like the School Nutrition Association and the National Association of State Boards of Education recommend that children eat as close to the middle of the school day as possible. It is more healthy for children to eat at consistent intervals of time, instead of going long stretches before eating lunch (a result of eating lunch late in the school day) or leaving a lot of time between lunch and an after school snack or dinner (a result of eating lunch early in the day). It is particularly important to include controls for mid-day eating, since this could be one of the good nutrition practices that lengthy lunch lengths are correlated with. The coefficients on length of day and length from start of day to lunch are not statistically significant, and the point estimates themselves hint at a negligible effect on BMI. The coefficient on the midday indicator is not significant, but is large and negative, suggesting that eating at midday is indeed helpful for children's health outcomes. The inclusion lowers the estimate on lunch length closer to zero when BMI is the dependent variable, but strengthens the estimate when the dependent variable is being overweight. These diverging effects suggest that the change in sample size is mostly responsible for changes in the estimates on lunch length, and even so, the new results are not far from the baseline estimates. These robustness checks suggest that the OLS estimates are not susceptible to averaging (above and beyond the measurement error effect), nor the inclusion of other controls.

### 5.3 Fixed Effects Estimates

In an effort to be more rigorous in uncovering the causal effect of lunch length on BMI, I re-estimate the baseline specification but now include school fixed effects. This approach eliminates any unobserved characteristics of schools that are common to students at the same school. This should eliminate any bias resulting from the fact that schools may systematically assign lunch lengths based on unobserved characteristics of the school and the children who attend it. Identification with school fixed effects relies on variation within a school in how long children are given to eat. In the SNDA-III data, this variation only occurs across grades, and moreover, only occurs for a small subset of schools. Of the 199 schools and 1,406 observations in the sample, only 305 students attend 44 schools where different lengths are assigned for different grades. Column (2) of Table 6 displays the results from the within estimator and column (1) repeats the results from the OLS estimator: For BMI, a 10 minute increase in assigned lunch length is now predicted to decrease BMI by 0.227 points, compared to an OLS estimate of 0.194 points. The estimate is not significant however, owing to the reduced variation in the regressors under a fixed effects estimator.

The estimates for the probability of being overweight and strictly overweight can not be directly compared across columns because the logit-fixed effects estimator does not provide consistent estimates of the fixed effects, which are needed to calculate the marginal effects. Instead, I present the odds ratio coefficient of both the logit-OLS estimator and the logit-fixed effects estimator in the tables. The fixed effects estimates are more than double the OLS estimates, but one explanation could be the change in sample size from 1,406 observations to 1,358. For schools where all children share the same outcome (i.e. all students are classified as overweight) the school fixed effect is a perfect predictor of outcomes, and hence these observations are dropped from the estimation [27]. Consequently, I limit further comparisons of the OLS and fixed effects results to the estimates when BMI is the dependent variable.

Although the difference between the estimators is not large, a comparison of their magnitudes is warranted. Presumably, if there are unobserved school factors biasing the OLS estimates, the bias would drive the OLS estimates to be biased downward (in this case, making the estimate too negative). That is because unobserved "good nutrition practices" reduce BMI and at the same time are presumably positively correlated with lunch length.[13] If the fixed effects mitigates the bias, the FE estimates should be larger (i.e. less negative) than the OLS estimates , however the opposite occurs.[14]

What can explain this relationship? One potential answer is that the types of schools that offer lengthy lunches may be those that don't practice other good nutrition practices such as requiring rigorous

[13]Formally, suppose $\epsilon_{is}$ includes a non-random school specific component $\alpha_s$ reflecting "good nutrition practices" of the school, and a random component $\mu_{is}$ (this ignores any individual specific unobserved terms, $\theta_i$). Then the formula for the bias in OLS is $\beta_{ols} = \beta_{true} - \frac{cov(\alpha_s, l_{is})}{var(l_{is})}$. This is because $\alpha_s$ is presumed to negatively impact BMI: $h_{is} = \beta_1 + \beta_2 L_{is} + \beta_3 X_{is} + \beta_4 S_s - \alpha_s + \mu_{is}$.

[14]It is well known that a fixed effects estimator will exacerbate any issues with measurement error. Since it was pointed out in Table 5 that some of the lunch lengths had to be averaged, and this can be formulated as a form of measurement error, I re-estimate the fixed effects estimate for BMI and exclude those observations that were averaged. The result is a coefficient estimate of : -.0261214 (s.e.=0.036672). This is similar to the estimate obtained when theses observations are included (-0.02273 (s.e.=0.03144)), indicating that the measurement error does not pose a significant role in the magnitude of the fixed effects estimates.

physical education programs or restricting access to "junk" food, and hence the unobservables and lunch length are actually negatively correlated. Although this may seem counterintuitive, schools may view lengthy lunches, stringent exercise requirements, and serving nutrient rich food as substitute policies for one another. For instance, time constraints may force schools to choose between an extra 10 minutes of physical education or adding 10 minutes onto children's lunches. Some schools may even take the stance that if they provide nutritious food and physical education classes, they are already doing "enough" to promote healthy eating habits. This is slightly evident in the raw data presented in Table 1. As can be seen, schools with the shortest lunch lengths have a much larger participation rate in nutrition programs (0.76 in 10 to 29 minute schools, and 0.53 in 31 to 40 minute schools) and are less likely to have vending machines or school snack bars on campus (0.6 versus 0.79).

A second explanation centers around the small number of observations that are used for identification. Only 20% of students attend schools that assign children different lengths of time to eat, and so differences in lunch length are not useful to explain differences in BMI within a school for 80% of the population. It could be that the fixed effects estimates are an artifact of the schools that have this type of variation. To assess this, in column (3) of Table 6, I present the OLS estimates using only the children who attend the 44 schools that offer different lunch lengths. In column (4), I display the school fixed effects estimates from this sample (note: all standard and additional controls are included in the regressions). As can be seen, the magnitude of the OLS estimates are much higher (absolute value) in this sample compared to the OLS results from the entire sample suggesting the sample may be unique. Moreover, the fixed effects estimates exhibit the same relationship with the OLS estimates as in the entire sample.

It is important to note that the school fixed effects approach cannot eliminate the bias that occurs if there is a systematic self-selection of children into schools with a particular lunch length. There is no way to control for this selection bias given the nature of available data, however there are a couple of indications that this bias may not be severe. First, recall from Table 4 that when the additional child and parent controls are included, the point estimates on lunch length do not change substantially, despite the fact that these nutrition and exercise practices are relevant predictors of BMI. This suggests that if important differences in observed characteristics do not diminish the finding, it is unlikely that differences in unobserved individual factors will either.

Second, there is some anecdotal evidence suggesting that the length of school lunches are determined (or at the very least, influenced) at an aggregate level by school district and state policies. According to data collected by the CDC in the School Health Policies and Programs Study survey (hereafter, SHPPS), school districts and states often require or recommend that the schools within their jurisdiction offer a certain minimum amount of time for lunch.[15] Of the 448 districts surveyed in the SHPPS, 169 (38%) districts require their schools to offer a minimum amount, 185 (41%) recommend a minimum to their schools, and the remaining 94 districts have no policy. By state, 6 states require schools to offer a minimum, 26 states recommend a minimum, and 18 have no policy.[16] If these requirements or recommendations are binding, we'd expect schools that are required by the district or state to provide a minimum to have higher average lunch lengths than those that only receive recommendations or are not subject to any restrictions. This turns out to be true: The average lunch length among schools whose districts require a minimum is 25.52 [s.d.=9.69] minutes (132 schools), while the average length at the 270 schools that are only recommended a minimum is 22.01 [7.80], and finally the average for schools that are not subject to any requirement or recommendation is 22.28 [8.55] (150 schools).[17]

It can not be determined whether and which schools in the SNDA-III data are required/recommended/neither to give minimum lunch periods, but the existence of these district/state level policies suggests that many schools within an area are subject to similar rules and hence will offer similar lunch lengths. This makes it less likely that a family will choose a particular school because of its lunch length, since all the schools in the area are similar in that capacity. Selection would have to occur at a more aggregate level-district or state-and this is a less probable occurrence.[18]

## 6 Conclusion

Can school nutrition policies partially explain the high rate of overweight school children in the U.S.? Children spend over 900 hours a year in school, and many of their lifestyle habits are developed within the school environment. Researchers have examined the role of various school nutrition practices and policies on children's health, but one that had yet to be explored is the length of time children are given to eat lunch in school. Medical evidence suggests that the length of a meal is important because of the timing of when an individual eats and when he realizes that he is full. Given that children eat over 180 lunches in school each year, and that lunch lengths typically range from from 15 to 60 minutes,

[15]In the SHPPS, school districts and states were not asked what this minimum time is, just whether or not one is required, recommended, or neither.

[16]The six states requiring schools within their state to offer a minimum are: Delaware, Kansas, Nevada, New Mexico, South Carolina, and West Virginia.

[17]By state the averages are: Require minimum: 24.64 [9.99] minutes at 28 schools; Recommend minimum: 22.59 [7.71] minutes at 307 schools, No policy: 22.45 [8.54] minutes at 219 schools.

[18]Note the SHPPS does not contain child level data, hence the effect of lunch length on BMI and health can not be estimated using this data.

there can be important implications of lunch length for children's nutritional health.

Using data from the SNDA-III, I estimate the effect of school lunch length on long term indicators of nutritional health, specifically BMI, being overweight, and being strictly overweight. The OLS estimates indicate that a 10 minute increase in assigned lunch length decreases a child's BMI by 0.187 points, and decreases the probability of being overweight by 1.83 percentage points. There is some concern that the OLS estimates do not measure the causal effect of lunch length, and I approach this issue in two ways. First, I show that the effect of lunch length on nutritional health does not change substantially when important school characteristics are included, nor when controls for children's exercise and nutrition practices are included. The estimates from this more extensive regression suggest that a 10 minute increase in lunch length decreases BMI by 0.194 points and reduces the probability of being overweight by 1.86 percentage points. The proximity of the results to one another suggest that differences among children and schools in important observable characteristics do not explain the negative relationship between lunch length and BMI, so presumably neither do differences in unobserved characteristics. To be more complete however, I use a school fixed effects estimate which controls for any unobserved characteristics of schools that may affect the child's health as well as lunch length. The fixed effects estimates are similar to the OLS estimates, and are only slightly larger in absolute value: A 10 minute increase in assigned lunch length decreases BMI by 0.227 points. Although identification is primarily based on a small number of schools, these results still suggest that a short lunch length increases a child's BMI and probability of being overweight.

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Table 1: Descriptive Statistics of Lunch Periods

| | Avg. Lunch Length (min) | Avg. Service Time (min) | Avg. Size of School | Avg. # Kids Eating | Starting Time of: Earliest Lunch | Latest Lunch | Ending Time of: Earliest Lunch | Latest Lunch | N Schools |
|---|---|---|---|---|---|---|---|---|---|
| One Period | | | | | | | | | |
| 1 | 49.60 | 6.39 | 1072.20 | 556.07 | 9:30 AM | 12:49 PM | 10:16 AM | 1:29 PM | 23 |
| [s.d.] | [26.89] | [4.25] | [804.94] | [680.45] | | | | | |
| Two Periods | | | | | | | | | |
| 1 | 33.50 | 5.47 | 716.91 | 252.33 | 10:26 AM | 12:10 PM | 10:56 AM | 12:40 PM | 44 |
| | [10.06] | [4.05] | [607.29] | [309.24] | | | | | |
| 2 | 32.75 | | | 242.29 | 11:11 AM | 1:10 PM | 11:41 AM | 1:44 PM | |
| | [7.3] | | | [309.81] | | | | | |
| Three Periods | | | | | | | | | |
| 1 | 34.71 | 5.28 | 968.69 | 266.94 | 10:11 AM | 11:59 AM | 10:41 AM | 12:39 PM | 57 |
| | [11.19] | [3.3] | [922.02] | [244.78] | | | | | |
| 2 | 34.07 | | | 265.94 | 10:41 AM | 12:45 PM | 11:11 AM | 1:15 PM | |
| | [8.55] | | | [234.36] | | | | | |
| 3 | 34.71 | | | 273.50 | 11:11 AM | 1:30 PM | 11:41 AM | 2:00 PM | |
| | [8.5] | | | [240.51] | | | | | |
| Four Periods | | | | | | | | | |
| 1 | 33.42 | 7.39 | 985.54 | 215.74 | 10:00 AM | 11:55 AM | 11:00 AM | 12:30 AM | 38 |
| | [9.79] | [4.51] | [595.68] | [260.07] | | | | | |
| 2 | 34.00 | | | 213.18 | 10:40 AM | 12:30 PM | 11:21 AM | 1:00 PM | |
| | [9.65] | | | [251.31] | | | | | |
| 3 | 32.21 | | | 210.25 | 11:04 AM | 1:00 PM | 11:45 AM | 1:30 PM | |
| | [8.76] | | | [257.95] | | | | | |
| 4 | 33.94 | | | 217.73 | 11:28 AM | 1:35 PM | 12:18 PM | 2:05 PM | |
| | [8.73] | | | [255.22] | | | | | |
| Five Periods | | | | | | | | | |
| 1 | 30.00 | 4.00 | 694.99 | 120.86 | 9:55 AM | 11:35 PM | 10:25 AM | 12:15 PM | 10 |
| | [6.23] | [2.44] | [572.04] | [42.06] | | | | | |
| 2 | 30.40 | | | 125.42 | 10:25 AM | 11:50 PM | 11:00 AM | 12:30 PM | |
| | [5.62] | | | [56.8] | | | | | |
| 3 | 30.60 | | | 119.83 | 11:00 AM | 12:00 PM | 11:30 AM | 12:25 PM | |
| | [7.54] | | | [54.31] | | | | | |
| 4 | 28.90 | | | 143.30 | 11:30 AM | 12:30 PM | 12:00 PM | 12:55 PM | |
| | [5.76] | | | [56.67] | | | | | |
| 5 | 29.00 | | | 129.47 | 12:00 PM | 12:50 PM | 12:30 PM | 1:20 PM | |
| | [5.67] | | | [56.72] | | | | | |
| Six Periods | | | | | | | | | |
| 1 | 29.38 | 4.33 | 625.48 | 83.25 | 10:04 AM | 11:25 PM | 10:28 AM | 11:55 AM | 21 |
| | [8.81] | [2.43] | [269.52] | [62.2] | | | | | |
| 2 | 28.28 | | | 88.39 | 10:32 AM | 11:40 AM | 10:56 AM | 12:10 PM | |
| | [9.61] | | | [58.9] | | | | | |
| 3 | 28.76 | | | 79.14 | 10:50 AM | 12:10 PM | 11:15 AM | 12:40 PM | |
| | [8.88] | | | [53.11] | | | | | |
| 4 | 28.09 | | | 75.05 | 10:55 AM | 12:45 PM | 11:20 PM | 1:15 PM | |
| | [8.32] | | | [55.61] | | | | | |
| 5 | 28.8 | | | 103.98 | 11:00 AM | 1:20 PM | 11:25 PM | 1:50 PM | |
| | [8.32] | | | [62.47] | | | | | |
| 6 | 27.19 | | | 98.20 | 11:05 AM | 1:55 PM | 11:30 PM | 2:22 PM | |
| | [7.55] | | | [59.65] | | | | | |
| Seven Periods | | | | | | | | | |
| 1 | 30.00 | 2.40 | 804.10 | 168.00 | 10:40 AM | 11:12 AM | 11:25 | 11:32 AM | 5 |
| | [9.35] | [1.51] | [516.09] | [41.31] | | | | | |
| 2 | 30.00 | | | 154.00 | 10:50 AM | 11:32 AM | 11:15 AM | 11:52 AM | |
| | [9.35] | | | [49.65] | | | | | |
| 3 | 30.00 | | | 156.55 | 10:55 AM | 11:52 AM | 11:20 AM | 12:12 PM | |
| | [9.35] | | | [47.57] | | | | | |
| 4 | 30.00 | | | 143.46 | 11:00 AM | 12:25 PM | 11:25 AM | 12:55 PM | |
| | [9.35] | | | [57.01] | | | | | |
| 5 | 25.00 | | | 149.50 | 11:05 AM | 12:55 PM | 11:30 AM | 1:25 PM | |
| | [5] | | | [57.12] | | | | | |
| 6 | 30.00 | | | 162.83 | 11:10 AM | 1:30 PM | 11:35 AM | 2:00 PM | |
| | [9.35] | | | [45.73] | | | | | |
| 7 | 49.00 | | | 139.07 | 11:12 AM | 2:00 PM | 1:12 PM | 2:30 PM | |
| | [40.06] | | | [67.3] | | | | | |
| Eight Periods | | | | | | | | | |
| 1-8 | 20.00 | 2.00 | 1095.71 | 125 to 250 | 11:21 AM | 1:50 PM | 11:41 PM | 2:10 PM | |
| | [---] | [---] | [---] | per period | | | | | |

Note: These averages were calculated at the school level. Not all school principals answered the question regarding the number of children who eat in a lunch period, and so these estimates are based on the schools where answers were provided. There is only one school in the sample that has 8 lunch periods.

Table 2: Characteristics of Children and Schools by Lunch Period Length

| | **10 to 29 min** (N=338) | **30 min** (N=490) | **31 to 40 min** (N=346) | **41 plus min** (N=234) | **All** (N=1,408) |
|---|---|---|---|---|---|
| Outcomes | | | | | |
| BMI | 21.263 | 23.596 | 22.359 | 21.546 | 22.391 |
| [s.d.] | [5.291] | [6.391] | [5.554] | [5.728] | [5.902] |
| Overweight | 0.387 | 0.436 | 0.398 | 0.367 | 0.404 |
| | [0.487] | [0.496] | [0.490] | [0.483] | [0.49] |
| Strictly Overweight | 0.192 | 0.257 | 0.234 | 0.213 | 0.228 |
| | [0.394] | [0.437] | [0.424] | [0.41] | [0.42] |
| Avg. Lunch Length | 23.523 | 30 | 36.531 | 54.413 | 34.107 |
| | [3.087] | [0.000] | [2.964] | [16.848] | [12.42] |
| School Characteristics | | | | | |
| Grade Span: K to 2 | 0.393 | 0.197 | 0.294 | 0.397 | 0.301 |
| | [0.489] | [0.398] | [0.456] | [0.49] | [0.459] |
| 3 to 5 | 0.44 | 0.238 | 0.364 | 0.452 | 0.353 |
| | [0.497] | [0.426] | [0.481] | [0.498] | [0.478] |
| 6 to 8 | 0.526 | 0.479 | 0.462 | 0.405 | 0.474 |
| | [0.5] | [0.5] | [0.499] | [0.492] | [0.499] |
| 9 to 12 | 0.239 | 0.459 | 0.329 | 0.307 | 0.349 |
| | [0.427] | [0.498] | [0.47] | [0.462] | [0.476] |
| Average Daily | 683.483 | 1013.066 | 821.59 | 1094.381 | 900.408 |
| Attendance | [501.1] | [706.768] | [508.537] | [1258.076] | [763.398] |
| School Serves | 0.846 | 0.891 | 0.953 | 0.918 | 0.9 |
| Breakfast | [0.361] | [0.31] | [0.21] | [0.273] | [0.299] |
| Recess | 0.568 | 0.257 | 0.384 | 0.452 | 0.395 |
| | [0.496] | [0.437] | [0.487] | [0.498] | [0.489] |
| Eat in Cafeteria | 0.931 | 0.985 | 1 | 0.965 | 0.973 |
| | [0.252] | [0.118] | [0] | [0.182] | [0.162] |
| Eat on Campus | 0.316 | 0.351 | 0.312 | 0.337 | 0.33 |
| | [0.465] | [0.477] | [0.464] | [0.473] | [0.47] |
| Eat off Campus | 0.029 | 0.142 | 0.13 | 0.136 | 0.111 |
| | [0.169] | [0.35] | [0.336] | [0.344] | [0.314] |
| Leave Eating Area | 0.357 | 0.491 | 0.586 | 0.414 | 0.47 |
| Before Lunch Ends | [0.48] | [0.5] | [0.493] | [0.493] | [0.499] |
| Vending Machine | 0.6 | 0.795 | 0.797 | 0.517 | 0.703 |
| | [0.49] | [0.403] | [0.402] | [0.5] | [0.457] |
| School Store or | 0.136 | 0.271 | 0.245 | 0.209 | 0.222 |
| Snack Bar | [0.343] | [0.445] | [0.431] | [0.407] | [0.415] |
| School Nutrition | 0.76 | 0.6 | 0.534 | 0.615 | 0.625 |
| Program | [0.427] | [0.49] | [0.499] | [0.487] | [0.484] |
| Avg Service Time | 5.263 | 5.259 | 6.436 | 5.662 | 5.616 |
| | [2.759] | [3.666] | [4.257] | [4.429] | [3.798] |
| Child Characteristics | | | | | |
| Age | 11.6 | 13.379 | 12.511 | 11.829 | 12.481 |
| | [3.065] | [2.965] | [3.319] | [3.464] | [3.245] |
| Female | 0.5147 | 0.512 | 0.482 | 0.504 | 0.504 |
| | [0.5] | [0.5] | [0.5] | [0.501] | [0.5] |
| Minority | 0.248 | 0.428 | 0.335 | 0.47 | 0.3693 |
| | [0.432] | [0.495] | [0.472] | [0.5] | [0.482] |
| Receive Reduced or | 0.346 | 0.469 | 0.473 | 0.538 | 0.452 |
| Free Lunch | [0.476] | [0.499] | [0.5] | [0.499] | [0.497] |
| Regularly Eat Breakfast | 0.751 | 0.726 | 0.728 | 0.756 | 0.737 |
| | [0.432] | [0.446] | [0.445] | [0.43] | [0.439] |
| Eat School Lunch 3+ | 0.742 | 0.742 | 0.736 | 0.743 | 0.741 |
| Times per Week | [0.437] | [0.437] | [0.44] | [0.437] | [0.437] |
| Child's Grade* | | | | | |

Table 2 (cont.): Characteristics of Children and Schools by Lunch Period Length

| | **10 to 29 min** (N=338) | **30 min** (N=490) | **31 to 40 min** (N=346) | **41 plus min** (N=234) | **All** (N=1,408) |
|---|---|---|---|---|---|
| Children Characteristics (cont.) | | | | | |
| Takes Vitamins | 0.556 | 0.585 | 0.586 | 0.589 | 0.579 |
| [s.d.] | [0.497] | [0.493] | [0.493] | [0.492] | [0.493] |
| Drinks Milk | 0.423 | 0.524 | 0.508 | 0.465 | 0.486 |
| | [0.494] | [0.499] | [0.5] | [0.499] | [0.499] |
| Child Is Healthy | 0.822 | 0.802 | 0.806 | 0.786 | 0.805 |
| | [0.382] | [0.398] | [0.395] | [0.41] | [0.396] |
| Child Eats More than Average | 0.236 | 0.232 | 0.242 | 0.26 | 0.24 |
| | [0.425] | [0.422] | [0.429] | [0.439] | [0.427] |
| Child Eats Less than Average | 0.174 | 0.144 | 0.127 | 0.158 | 0.149 |
| | [0.38] | [0.352] | [0.333] | [0.365] | [0.357] |
| Takes Phys Ed | 0.816 | 0.673 | 0.751 | 0.794 | 0.747 |
| | [0.387] | [0.469] | [0.432] | [0.404] | [0.434] |
| Plays on Sports Team | 0.579 | 0.589 | 0.569 | 0.632 | 0.589 |
| | [0.494] | [0.492] | [0.495] | [0.483] | [0.492] |
| Plays Outside (regularly) | 0.869 | 0.902 | 0.89 | 0.893 | 0.889 |
| | [0.336] | [0.297] | [0.313] | [0.309] | [0.313] |
| Hrs TV per Day | 1.732 | 1.864 | 1.919 | 1.82 | 1.838 |
| | [1.185] | [1.286] | [1.404] | [1.174] | [1.275] |
| Hrs Computer per Day | 1.028 | 1.324 | 1.202 | 1.195 | 1.201 |
| | [1.344] | [1.259] | [1.342] | [1.512] | [1.348] |
| Parent Characteristics | | | | | |
| Income: 15 to 30 K | 0.124 | 0.236 | 0.202 | 0.226 | 0.199 |
| | [0.33] | [0.425] | [0.402] | [0.419] | [0.399] |
| 30 to 40 K | 0.13 | 0.1 | 0.132 | 0.098 | 0.115 |
| | [0.336] | [0.3] | [0.34] | [0.298] | [0.319] |
| 40 to 60 K | 0.144 | 0.157 | 0.164 | 0.119 | 0.149 |
| | [0.352] | [0.364] | [0.371] | [0.325] | [0.357] |
| 60 to 80 K | 0.171 | 0.14 | 0.147 | 0.123 | 0.147 |
| | [0.377] | [0.348] | [0.355] | [0.33] | [0.354] |
| 80 to 100 K | 0.082 | 0.077 | 0.083 | 0.089 | 0.082 |
| | [0.276] | [0.267] | [0.277] | [0.286] | [0.275] |
| 100 Plus K | 0.218 | 0.144 | 0.141 | 0.145 | 0.161 |
| | [0.414] | [0.352] | [0.349] | [0.353] | [0.368] |
| Employed | 0.958 | 0.932 | 0.919 | 0.901 | 0.93 |
| | [0.199] | [0.25] | [0.273] | [0.298] | [0.254] |
| Income Assistance | 0.213 | 0.281 | 0.248 | 0.346 | 0.267 |
| | [0.41] | [0.45] | [0.432] | [0.476] | [0.442] |
| Speak English | 0.899 | 0.848 | 0.895 | 0.829 | 0.869 |
| | [0.301] | [0.358] | [0.305] | [0.377] | [0.337] |
| Educ: High School | 0.248 | 0.253 | 0.274 | 0.209 | 0.25 |
| | [0.432] | [0.435] | [0.446] | [0.407] | [0.433] |
| Some College | 0.319 | 0.377 | 0.349 | 0.337 | 0.35 |
| | [0.466] | [0.485] | [0.477] | [0.473] | [0.477] |
| College | 0.221 | 0.136 | 0.167 | 0.183 | 0.172 |
| | [0.416] | [0.343] | [0.374] | [0.388] | [0.378] |
| Professional | 0.118 | 0.132 | 0.095 | 0.106 | 0.115 |
| | [0.323] | [0.339] | [0.294] | [0.309] | [0.32] |
| Married | 0.786 | 0.685 | 0.739 | 0.683 | 0.723 |
| | [0.41] | [0.464] | [0.439] | [0.466] | [0.447] |
| Number HH Members | 4.31 | 4.446 | 4.473 | 4.482 | 4.426 |
| | [1.161] | [1.397] | [1.347] | [1.599] | [1.369] |
| Geographic & Interview Date Characteristics | | | | | |
| Urbanicity (rural, urban, suburban); Region (Northeast, Midwest, etc…); Month of Interview (January-June)* | | | | | |

Note: * Indicates that controls for child's grade, urbanicity, region and month of interview are included as dummy variables. Averages are not provided in the table for brevity.

Table 3: OLS Estimates-Effect of Lunch Period Length on Children's Health (standard regressors)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | **Dependent Variable: BMI** | | | | | | |
| Length of Lunch Period (min) | -0.02036 | -0.02362 | -0.02142 | -0.01784 | -0.02753 | -0.01955 | -0.01875 |
| [s.e.] | [0.01399] | [0.01539] | [0.00934]** | [0.00847]** | [0.01406]** | [0.00837]** | [0.00849]** |
| $R^2$ | 0.0104 | 0.0435 | 0.1578 | 0.2198 | 0.0524 | 0.2338 | 0.2513 |
| F-Stat on Regressors | -- | F(13,198) = 2.08 | F(7, 198) = 28.28 | F( 15, 198) = 31.05 | F(8, 198) = 5.09 | F(23,198) = 21.47 | F(43,198) = 13.67 |
| [p-value] | | [0.0170] | [0.0000] | [0.0000] | [0.0000] | [0.0000] | [0.0000] |
| | **Dependent Variable: Overweight (85th and above percentile)** | | | | | | |
| Length of Lunch Period | -0.0013216 | -0.0012875 | -0.0019547 | -0.0017516 | -0.0016789 | -0.0018772 | -0.0018352 |
| [s.e.] | [0.00116] | [0.00124] | [0.001]** | [0.00111] | [0.00112] | [0.00105]* | [0.00098]* |
| Pseudo $R^2$ | 0.0009 | 0.016 | 0.011 | 0.0166 | 0.0133 | 0.0219 | 0.0402 |
| $\chi^2$ Stat on Regressors | -- | $\chi^2$ (13) = 26.37 | $\chi^2$ (7) = 29.50 | $\chi^2$ (15) = 32.98 | $\chi^2$ (8) = 19.98 | $\chi^2$ (23) = 44.19 | $\chi^2$ (43) =116.49 |
| [p-value] | | [0.0152] | [0.0001] | [0.0047] | [0.0104] | [0.005] | [0.0000] |
| | **Dependent Variable: Strictly Overweight (95th and above percentile)** | | | | | | |
| Length of Lunch Period | -0.0002877 | -0.000244 | -0.0008747 | -0.0006146 | -0.0006498 | -0.0008139 | -0.0006677 |
| [s.e.] | [0.00078] | [0.00075] | [0.00072] | [0.0007] | [0.00077] | [0.00067] | [0.00065] |
| Pseudo $R^2$ | 0.0003 | 0.019 | 0.0136 | 0.0308 | 0.0242 | 0.0436 | 0.0631 |
| $\chi^2$ Stat on Regressors | -- | $\chi^2$ (13) = 24.18 | $\chi^2$(7) = 16.62 | $\chi^2$(15) = 50.80 | $\chi^2$(8) = 35.74 | $\chi^2$(23) = 81.63 | $\chi^2$(43) = 123.21 |
| [p-value] | | [0.0296] | [0.0201] | [0.000] | [0.000] | [0.000] | [0.000] |
| | **Control Variables in Regressions** | | | | | | |
| School Characteristics | N | N | Y | N | N | N | Y |
| Child Characteristics | N | N | N | Y | N | Y | Y |
| Parent Characteristics | N | N | N | N | Y | Y | Y |
| Geographic/Interview Date | N | Y | N | N | N | N | Y |
| N= 1,408 | | | | | | | |

Note: BMI and Percentile were calculated by the SNDA-III survey administrators. Each child was assigned a percentile based on their BMI, and a historic BMI growth chart for age and sex developed by the Center for Disease Control.
This study uses two standard definitions of being overweight: A child is "Overweight" if he/she is in the 85th or higher BMI percentile, and "Strictly Overweight" if he/she is in the 95th or higher percentile.
The estimates for the binary dependent variables-"Overweight" and "Strictly Overweight" are estimated using a logit specification. The marginal effects are reported in the table.
The following variables are included in the regressions where appropriate. These controls are referred to as "Standard Controls" throughout the text and tables.
(i) Geographic & Interview: Month of Interview Dummies, Urbanicity Dummies, Region Dummies
(ii) School Characteristics: Grade Span of School, Average Daily Attendance, Existence of School Breakfast Program, Existence of Recess
(iii) Parent Characteristics: Income, Employment Status, Family Receives Government Assistance
(iv) Child Characteristics: Age, Sex, Minority Status, Grade, Receives Free/Reduced Price Lunch
Standard errors (in brackets) are clustered at the school level to account for any intragroup correlation. * denotes statistically different from zero at 10%, ** at 5%.

Table 4: OLS Estimates-Effect of Lunch Period Length on Children's Health (additional regressors)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | **Dependent Variable: BMI** | | | | | |
| Length of Lunch Period (min) | -0.01875 | -0.01841 | -0.01864 | -0.01919 | -0.01919 | -0.01947 |
| [s.e.] | [0.00849]** | [0.00875]** | [0.00748]*** | [0.00859]** | [0.00742]*** | [0.00764]*** |
| $R^2$ | 0.2513 | 0.2549 | 0.3756 | 0.255 | 0.3792 | 0.3833 |
| F-Stat on Regressors | F(43,198) = 13.67 | F( 8, 198) = 0.82 | F( 12, 198) = 22.46 | F( 7, 198) = 0.89 | F( 19, 198) = 15.15 | F( 27, 198) = 12.62 |
| [p-value] | [0.0000] | [0.5826] | [0.0000] | [0.5167] | [0.0000] | [0.0000] |
| | **Dependent Variable: Overweight (85th and above percentile)** | | | | | |
| Length of Lunch Period | -0.00183 | -0.00185 | -0.00175 | -0.00184 | -0.00174 | -0.00186 |
| [s.e.] | [0.00098]* | [0.00097]** | [0.00109]* | [0.00096]** | [0.00107]* | [0.00106]* |
| Pseudo $R^2$ | 0.0402 | 0.0414 | 0.1505 | 0.0478 | 0.1595 | 0.1618 |
| $\chi^2$ Stat on Regressors | $\chi^2$(43) =116.49 | $\chi^2$( 8) = 3.53 | $\chi^2$( 12) = 156.50 | $\chi^2$( 7) = 11.62 | $\chi^2$( 19) = 177.23 | $\chi^2$( 27) = 195.39 |
| [p-value] | [0.0000] | [0.897] | [0.0000] | [0.1139] | [0.0000] | [0.0000] |
| | **Dependent Variable: Strictly Overweight (95th and above percentile)** | | | | | |
| Length of Lunch Period | -0.00066 | -0.0006 | -0.00042 | -0.00072 | -0.00046 | -0.00046 |
| [s.e.] | [0.00065] | [0.00069] | [0.00065] | [0.00065] | [0.00064] | [0.00067] |
| Pseudo $R^2$ | 0.0631 | 0.0662 | 0.1814 | 0.0699 | 0.1904 | 0.1952 |
| $\chi^2$ Stat on Regressors | $\chi^2$(43) = 123.21 | $\chi^2$( 8) = 5.33 | $\chi^2$( 12) = 140.86 | $\chi^2$( 7) = 8.66 | $\chi^2$( 19) = 148.51 | $\chi^2$( 27) = 169.15 |
| [p-value] | [0.000] | [0.7223] | [0.0000] | [0.2777] | [0.0000] | [0.0000] |
| | **Control Variables in Regressions** | | | | | |
| School Characteristics | S=Standard | S + Additional | S | S | S | All |
| Child Characteristics | S | S | S + Additional | S | S + Additional | All |
| Parent Characteristics | S | S | S | S + Additional | S + Additional | All |
| Geographic/Interview Date | S | S | S | S | S | All |
| N=1,408 | | | | | | |

Note: The estimates for the binary dependent variables-"Overweight" and "Strictly Overweight" are estimated using a logit specification. The marginal effects are reported in the table. Standard controls are those listed in Table 3. Each column starting from Column (2) adds additional school, child, and parent characteristics, and Column (6) show the results when all standard and additional controls are added. The results in Column (6) are referred to in the text as the "Baseline" results. and the additional contrrols are referred to as "Additional Controls". These extra controls include:

(i) Additional School Characteristics: Dummies for lunch location (cafeteria, other campus location, off campus), Presence of vending machines, snack bar, average time spent in food service line, whether children remain in eating area for entire period or can move, existence of certified nutrition program

(ii) Additional Parent Characteristics: Is english main language in household, parents highest education, marital status, number of household members

(iii) Additional Child Characteristics: Whether child regularly eats breakfast, purchases lunch 3x per week, takes vitamins, drinks skim milk, considered healthy (based on parents opinion), eats more/less than physical education average child (parents opinion), whether child takes phys ed classes, plays on sports team, regularly exercises/plays, average time spent per day watching tv and using the computer.

Standard errors (in brackets) are clustered at the school level to account for any intragroup correlation. * denotes statistically different from zero at 10%, ** at 5%.

Table 5: Robustness Checks

| | **BMI** | **Overweight** (85th and above percentile) | **Strictly Overweight** (95th and above percentile) |
|---|---|---|---|
| **Baseline** | | | |
| Length of Lunch Period (min) | -0.01947 | -0.00186 | -0.00046 |
| [s.e.] | [0.00764]*** | [0.00106]* | [0.00067] |
| $R^2$ or Pseudo $R^2$ | 0.3833 | 0.1618 | 0.1952 |
| N | 1,408 | | |
| **Omit Averaged Lunch Lengths** | | | |
| Length of Lunch Period | -0.0202 | -0.00194 | -0.00047 |
| [s.e.] | [0.00823]*** | [0.00112]* | [0.00067] |
| $R^2$ or Pseudo $R^2$ | 0.3965 | 0.1766 | 0.2099 |
| N | 1,242 | | |
| **Include Number of Children Eating During Lunch Period** | | | |
| Length of Lunch Period | -0.01231 | -0.00127 | 0.00068 |
| [s.e.] | [0.01062] | [0.00144] | [0.00097] |
| Number of Kids Eating | 0.00095 | 0.000109 | 0.00005 |
| [s.e.] | [0.00065] | [0.00005]** | [0.00004] |
| $R^2$ or Pseudo $R^2$ | 0.3933 | 0.1735 | 0.2239 |
| N | 1,153 | | |
| **Include Length of Day, Length from Start of Day to Lunch, Midday Indicator** | | | |
| Length of Lunch Period | -0.0153 | -0.00203 | -0.00017 |
| [s.e.] | [0.00814]* | [0.00109]* | [0.00065] |
| Length: School Day | 0.00815 | 0.00055 | 0.0008 |
| [s.e.] | [0.00671] | [0.00069] | [0.00055] |
| Length: Start of Day to Lunch | 0.0001 | -0.00072 | 0.00017 |
| [s.e.] | [0.00542] | [0.00046] | [0.00033] |
| Eat within 30 min of Midday | -0.44616 | -0.04134 | -0.03291 |
| [s.e.] | [0.28052] | [0.03113] | [0.02264] |
| F-stat or $\chi^2$ of additional regressors | F( 3, 191) = 1.65 | chi2( 3) = 4.05 | chi2( 3) = 5.61 |
| [p-value] | 0.1794 | 0.2561 | 0.1322 |
| $R^2$ or Pseudo $R^2$ | 0.3824 | 0.1606 | 0.1993 |
| N | 1,358 | | |

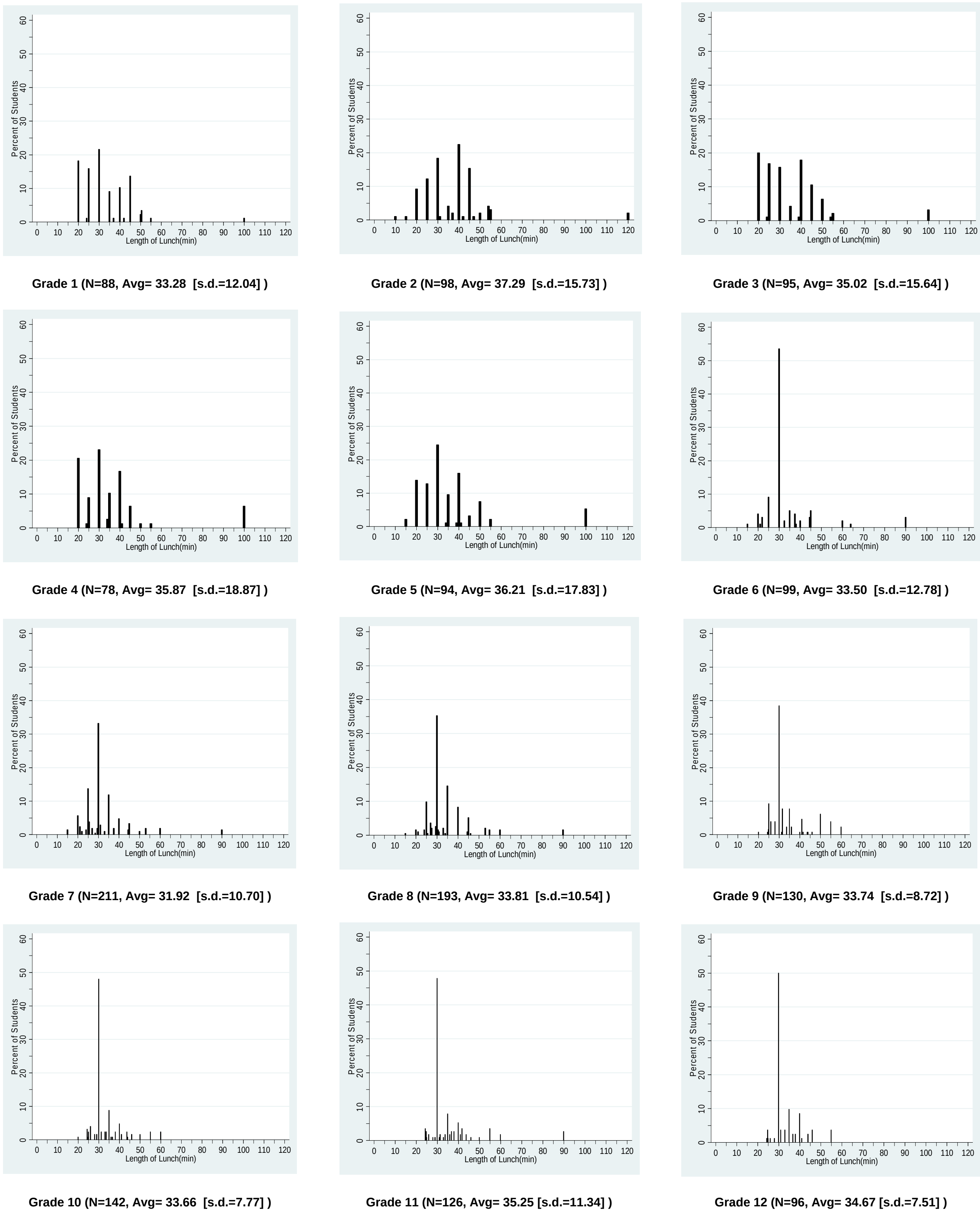
Note: The baseline regression estimates refer to the regression with all standard and additional controls (i.e. Column 6 of Table 4). The estimates for the binary dependent variables-"Overweight" and "Strictly Overweight" are estimated using a logit specification. The marginal effects are reported in the table.
"Number of kids" enters the regression in level form (not as a fraction of total student body), hence the interpretation is as follows: If the number of children eating during a child's lunch period increased by 100 students, then holding all else constant, that child's probability of being overweight increases by .109% (significantly different from zero).
Length of day and length from start of day to lunch are measured in minutes, and "eats within 30 minutes of midday" is an indicator variable equal to 1 if the child begins eating at least 30 minutes before or after the midpoint of the school day. Information on these variables were not reported by all schools, hence the lower sample size.
Standard errors (in brackets) are clustered at the school level to account for any intragroup correlation. * denotes statistically different from zero at 10%, ** at 5%.

Table 6: Fixed Effects Estimates-Effect of Lunch Period Length on Children's Health

| | Entire Sample | | Sample with Lunch Time Variation | |
|---|---|---|---|---|
| | OLS (Baseline) | Fixed Effects | OLS | Fixed Effects |
| | (1) | (2) | (3) | (4) |
| | **Dependent Variable: BMI** | | | |
| Length of Lunch Period (min) | -0.01947 | -0.02273 | -0.04576 | -0.07636 |
| [s.e.] | [0.00764]*** | [0.03144] | [0.03138] | [0.04621]* |
| $R^2$ | 0.3833 | 0.2371 (within) | 0.5133 | 0.3293 (within) |
| N | 1,408 | 1,408 | 305 | 305 |
| Number of Schools | 199 | 199 | 44 | 44 |
| | **Dependent Variable: Overweight (85th and above percentile)** | | | |
| Length of Lunch Period | | | | |
| *Marginal Effect* | -0.00186 | Marginal Effect N/A | -0.00461 | N/A |
| | [0.00106]* | | [0.0048] | |
| *Odds Ratio* | *-0.00789* | *-0.01736* | *-0.02247* | *-0.04629* |
| | *[0.00449]** | *[0.02010]* | *[0.02317]* | *[0.0225]* |
| Pseudo $R^2$ | 0.1618 | | 0.3175 | |
| N | 1,408 | 1,358 | 305 | 298 |
| Number of Schools | 199 | 183 | 44 | 41 |
| | **Dependent Variable: Strictly Overweight (95th and above percentile)** | | | |
| Length of Lunch Period | | | | |
| *Marginal Effect* | -0.00046 | N/A | 0.00111 | N/A |
| | [0.00067] | | [0.00224] | |
| *Odds Ratio* | *-0.00328* | *0.00976* | *0.01491* | *0.01746* |
| | *[0.00475]* | *[0.01973]* | *[0.02996]* | *[0.02687]* |
| Pseudo $R^2$ | 0.1952 | | 0.4264 | |
| N | 1,408 | 1143 | 305 | 260 |
| Number of Schools | 199 | 152 | 44 | 36 |

Note: The estimates in Columns (1) and (2) are calculated using the entire sample. Column (1) repeats the baseline estimates. The results for the binary dependent variables are calculated using a logit regression, and the marginal effects are displayed in the table. In addition, the odds ratio estimates are now presented in italics. Column (2) presents the school fixed effects estimates. The sample size changes for the binary dependent variables for the following reason: A fixed effects logit estimation drops all observations for a school if all students within that school have the same outcome, since in that case the fixed effect is a perfect predictor of the outcomes. Moreover, a fixed effects logit estimator does not consistently predict the individual school effects, hence marginal effects cannot be calculated. The odds ratio coefficient is presented instead, and can be compared to the to the odds ratio in Column (1). The estimates in Columns (3) and (4) use only the sample of students that attend schools that offer children in different grades different lengths of time to eat. Column (3) presents the OLS estimates for this sample and Column (4) presents the results of a fixed effects estimation from this sample of schools with lunch time variation. Again, the sample is smaller for the binary dependent variables , and marginal effects cannot be calculated for the reasons mentioned above.
Standard errors (in brackets) are clustered at the school level to account for any intragroup correlation. * denotes statistically different from zero at 10%, ** at 5%.

Figure 1: Histogram of Lunch Period Lengths by Grade




**Grade 1 (N=88, Avg= 33.28 [s.d.=12.04] )**

**Grade 2 (N=98, Avg= 37.29 [s.d.=15.73] )**

**Grade 3 (N=95, Avg= 35.02 [s.d.=15.64] )**

**Grade 4 (N=78, Avg= 35.87 [s.d.=18.87] )**

**Grade 5 (N=94, Avg= 36.21 [s.d.=17.83] )**

**Grade 6 (N=99, Avg= 33.50 [s.d.=12.78] )**

**Grade 7 (N=211, Avg= 31.92 [s.d.=10.70] )**

**Grade 8 (N=193, Avg= 33.81 [s.d.=10.54] )**

**Grade 9 (N=130, Avg= 33.74 [s.d.=8.72] )**

**Grade 10 (N=142, Avg= 33.66 [s.d.=7.77] )**

**Grade 11 (N=126, Avg= 35.25 [s.d.=11.34] )**

**Grade 12 (N=96, Avg= 34.67 [s.d.=7.51] )**